Public Health England

Protecting and improving the nation's health

Factors contributing to the transmission of COVID-19 within food manufacturing and processing settings

A rapid review

Contents

Main messages

1. This rapid review includes 6 studies: 3 outbreak investigations and 3 cross-sectional studies (search date: 1 January to 21 December 2020).

2. All 6 studies were deemed to be at risk of bias: none of them included a comparator group, it is possible that factors not considered in the studies impacted the results, and the facilities included in the studies might not be representative of the food manufacturing and processing industry.

3. Three outbreak investigations reported on outbreaks in meat processing plants (2 in the United States (US) and one in Germany). Difficulties in maintaining a 2-metre distance, especially in production areas, may be a risk factor for transmission in these settings.

4. Three cross-sectional studies reported on aggregated data of outbreaks in meat and poultry processing facilities in the US. The data on race and ethnicity reported in these studies suggest that Hispanic workers were more affected by coronavirus (COVID-19) than those of White or Black ethnicity, although factors such as health status were not taken into account. Supplementary evidence suggests that this might be linked to socioeconomic factors, such lack of access to economic or social support, over-crowded housing and language barriers.

5. Further studies of higher quality are required to assess i) whether these outbreaks are specific to meat or poultry processing settings, or more generally to food processing settings and ii) which risk factors (including structural, operational and socioeconomic) might be associated with COVID-19 transmission in these settings.

Background

Since the start of the pandemic, COVID-19 outbreaks in food manufacturing and processing settings have been reported in the media. Data from the US Centers for Disease Control and Prevention (CDC) suggests that food processing facilities (12% of CDC investigations) are high-risk settings, second on the list after long-term care facilities (26% of CDC investigations) (1). Similarly, data from the European Centre for Disease Prevention and Control (ECDC) shows that, excluding health and social care settings, more COVID-19 outbreaks were reported in food packaging and processing settings than in any other occupational settings. Between March and July 2020, 153 clusters (3,856 cases) in food packaging and processing settings were reported to the ECDC, compared to 77 (1,032 cases) clusters in factory and manufacturing settings and 65 (410 cases) in office settings (2). Based on the ECDC data, the countries with the highest number of cases in food packaging and processing settings were Ireland (1,154 cases), Spain (1,016 cases) and the UK (450 cases). Of the 153 clusters, 114 (2,529 cases) were in food processing settings and 26 (1,016 cases) were linked to the agriculture sector (2).

While genomic epidemiological studies of outbreaks in food processing settings, including in the UK (3) and in the US (4), have demonstrated that transmission has occurred within these settings, they do not provide evidence on drivers for transmission. Possible risk factors include occupational factors such as lack of social distancing, as well as socioeconomic factors (migrant and/or seasonal workers, low-income workers living in shared accommodation, for instance) (2,5). A report from the European Federation of Food Agriculture and Tourism Trade Unions published in June 2020 also noted that, in the UK, production levels had increased up to 40% due to panic-buying, which might have resulted in social distancing not being implemented on production lines (5).

Additional risk factors have also been considered, such as increased number of respiratory droplets emitted due to the need to speak more loudly over noise (6) as well as increased stability of the SARS-CoV-2 virus on surfaces due to low temperature and humidity conditions in food processing settings (7).

In this context, there is a need to identify whether there are particular factors driving COVID-19 transmission specific to food manufacturing and processing settings, or whether transmission is a result of other factors.

Objective

The purpose of this rapid review was to identify and assess evidence from COVID-19 outbreaks on factors contributing to the transmission of COVID-19 within food manufacturing and processing settings.

Definitions

‘Food processing’ and ‘food manufacturing’ refer to the production and packaging of foods and are often used interchangeably.

‘Food processing setting’ includes both ‘food processing facilities’ (where a specific item is produced; usually only refers to the buildings) and ‘food processing plants’ (where a specific process takes place; usually refers to the buildings and the machinery).

‘Meat processing facility’ refers to any establishment where animals are slaughtered, dressed, processed, cut, trimmed, wrapped, and/or packaged for sale for human consumption. A ‘meat processing plant’ will carry out one of these processes. ‘Meat packing facility’ is where the wholesale packaging of meat for sale takes place, and usually includes slaughtering, processing and redistribution to retailers.

Methodology

This report employed a rapid review approach to address the above review question. A literature search was undertaken to identify primary evidence related to the COVID-19 outbreak, published (or available as preprint) between 1 January 2020 and 21 December 2020.

Studies conducted in food manufacturing and processing settings, including meat-production settings, were considered. Studies conducted in food businesses other than food manufacturing and processing settings, such as farms or supermarkets, were excluded. Full details of the methodology are provided in Annexe A. A protocol was produced a priori and is available in Annexe C.

Evidence

Search results

The search returned 2,627 records. After removal of duplicates, 1,971 records were screened by title and abstract. Of these, 132 full-text articles were assessed for eligibility and 6 were included in this review. A PRISMA diagram is provided in Annexe A.

Three of the 6 studies included in this review reported on outbreak investigations in meat processing facilities, one in Germany (8) and 2 in the US (9,10). The 3 other studies were cross-sectional and reported on aggregated data of outbreaks in meat and poultry processing facilities across the US (11 to 13). Full details of these studies can be found in Annexe B.

All 6 studies were deemed to be at risk of bias: none of them included comparator or control groups and none of them were adjusted for other factors that might have impacted the results (confounding factors), such as individual risk factors (including weight, pre-existing health conditions, age or deprivation). In addition, the results of this rapid review might not be representative of the food manufacturing and processing industry (the cross-sectional studies did no report on facilities without COVID-19 cases, and no information on how facilities were selected was provided in the outbreak investigations).

Outbreak investigations

Gunther and others reported on an outbreak investigation in 2 meat processing plants in Germany (8). The outbreak started in one of the plants in mid-May 2020 and, following contact between employees of the 2 plants, spread to the second meat processing plant where more than 1,400 COVID-19 cases were identified throughout June 2020. Timing of events and genomic analyses suggested that the cases shared the same viral genome signature and that one single employee was likely to be the common source of infection in the initial cluster at the second plant (see Annexe B for more details). The study also reported on possible transmission routes. While some workers lived together and shared transport to work, the investigation suggests that the contact between index case and secondary cases happened in a processing plant where most of the staff worked at a fixed position in a conveyor-belt processing line. The positions of all RT-PCR-tested employees within the processing plant were mapped, including the suspected index case, secondary cases and negative cases, as well as data on virus genotypes. The data suggested that transmission might have occurred at up to 8 metres. The authors hypothesised that factors such as intense physical work, low fresh air exchange rate and continuous recirculation of cooled unfiltered air might have promoted long-range airborne transmission. However, other transmission routes (close contact or fomite) in other areas of the processing plant, such as canteen or bathroom, cannot be fully rulled out.

A meat processing facility in South Dakota, US, was the focus of an investigation of the state health department between 16 March and 25 April 2020 (9). Steinberg and others reported that 25.6% of the 3,635 employees tested positive to SARS-CoV-2, of which 96.3% were symptomatic. The highest proportion of employees with COVID-19 were reported in plants where most employees work on production lines at less than 2 metres apart. Differences were also seen according to employment status (26.8% of non-salaried with COVID-19 versus 14.8% of salaried). The authors noted that salaried employees tended to have workstations that could allow for social distancing.

Donahue and others performed interviews of staff with confirmed COVID-19 at a meat processing facility in the state of Nebraska, US (10). As part of a public health surveillance programme of the CDC, all employees were invited to undertake RT-PCR testing of the SARS-COV-2 virus. Of the 1,216 workers tested, 375 (31%) tested positive, of which 241 were interviewed for further analysis. Nearly half (46%) of those interviewed were Hispanic. Contact with a person diagnosed with COVID-19 or otherwise visibly ill at work was reported by 29% of those interviewed, of which 74% happened in production areas and 51% in cafeteria or rest areas.

Cross-sectional studies

Three papers were based on COVID-19 surveillance data among workers in meat and poultry processing facilities in the US, collected and published by the CDC (11 to 13). The first paper was based on data collected up to 27 April 2020 (11) and the two other papers reported on data collected up to 31 May 2020 (12,13). Based on the data from 14 states which reported total number of workers in meat and poultry processing facilities, 9.1% of the workers had tested positive to SARS-CoV-2, ranging from 3.1% to 24.5% per facility (12). The data on race and ethnicity suggested that Hispanic and Asian workers were more affected than those of White or Black ethnicity (12,13), but the data were not adjusted for possible confounders such as age, weight or pre-existing health conditions.

Possible reasons for increased COVID-19 risks in meat and poultry processing facilities were explored in one study, based on qualitative data from the facility risk assessments (11). The main structural and operational factors identified were difficulties in maintaining 2-metre distance while working and during breaks, difficulties in adhering to face covering recommendations due to the nature of the work, and difficulties in adhering to cleaning and disinfection guidance. Sociocultural and economic challenges were also identified, including sharing of transportation to and from work, living conditions of workers (crowded and multi-generational settings), language and cultural barriers in transmitting health and safety information in the workplace, and financial incentives such as attendance bonuses that could have encouraged staff to work whilst ill. However, it has to be noted that these results are based on an analysis of qualitative data from different outbreaks and that the individual-level data on each outbreak (such as the data used to identify common characteristics) were not provided.

Main findings

Evidence from descriptive studies suggest that transmission occurs within the meat processing plants rather than as a result of external factors (such as shared transportation to work as reported in one of the studies identified). The results of outbreak investigations suggest that production areas can increase transmission due to difficulties in maintaining a 2-metre distance. Evidence from the US suggests that Hispanic workers in meat and poultry processing facilities were more affected than those of White or Black ethnicity, although the results were not adjusted for possible confounders such as health status or deprivation, so this could have been influenced by factors other than race.

Supplementary evidence

In this section we discuss additional evidence that did not strictly meet the inclusion criteria but that provide some insights on the ethnicity and socioeconomic factors reported in the previous section.

Structured interviews conducted with poultry workers in the US have shown that foreign workers were more likely to work in fixed positions on the production floor (which involves physical proximity and was identified as a risk factor in this rapid review), to share transportation to work and to live with other poultry workers than US-born workers (14).

Community-based investigations were also conducted in the US to identify risk factors in Hispanic and Marshallese populations as they suffered higher rates of COVID-19 cases compared to White populations. Among Hispanic and Marshallese individuals with COVID-19, poultry processing was the most frequently reported occupation. Difficulties to quarantine and isolate have also been reported in both communities due to high-occupancy households and to the lack of access to economic or social support. In addition, lack of awareness of public health messages and lack of knowledge regarding COVID-19 have also been noted in these populations (15).

Similar socioeconomic factors were highlighted by the European Federation of Food Agriculture and Tourism Trade Unions report in relation to the outbreaks in UK meat processing plants which mainly employ migrants who tend to live in poor and overcrowded housing, do not necessarily understand English (so lack access to information) and are on low wages, so cannot afford to be on sick leave nor to self-isolate (5).

These results suggest that there might be an overlap between the sociocultural and economic challenges identified by Dyal and others in meat and poultry processing facilities in the US (11) and the higher rate of COVID-19 cases observed in these settings in Hispanic workers compared to Black and White workers (10,12,13). However, it is not possible to draw conclusions as these results do not take into account other factors (such as health status).

Limitations

This review includes only outbreak investigations and cross-sectional studies, which are limited based on their design: they are subject to bias, might not be representative, were not adjusted for potential confounding factors, and the absence of comparator groups do not allow for analysis of possible association between exposure and outcome.

Whilst effort has been made to highlight key sources of bias based on pre-determined categories, a formal risk of bias or quality assessment tool has not been used due to rapid methods. In addition, the evidence has not been graded, meaning it has not been possible to describe the strength of evidence in a transparent way.

As with all reviews, the evidence identified may be subject to publication bias, whereby null or negative results are less likely to have been published by the authors.

All 6 studies identified reported on outbreaks in meat and poulty processing settings, no evidence from other food processing settings were identified. It was not possible to evaluate whether these settings are at higher risk of COVID-19 transmission or whether this is due to publication bias.

Finally, 5 of the 6 studies identified were conducted in the US, and the results of these studies may not be applicable to the UK context.

Conclusions

The overall evidence on factors contributing to the transmission of COVID-19 within food manufacturing and processing settings is limited to 6 studies (3 outbreak investigations and 3 cross-sectional studies), mainly from meat and poultry processing facilities in the US. Difficulties in maintaining a 2-metre distance, mainly in production areas, might increase transmission in meat processing settings. Physical distancing was the risk factor identified most consistently by the studies within this rapid review.

Data from US meat and poultry processing facilities suggests that Hispanic workers were disproportionately affected by COVID-19 compared to White or Black workers. Supplementary evidence suggests that this might be linked to socioeconomic factors, such lack of access to economic or social support, over-crowded housing and language barriers.

More research is required to assess i) whether these outbreaks are specific to meat/poultry processing settings or more generally to food processing settings and ii) which risk factors (including structural, operational and socioeconomic factors) might be associated with COVID-19 transmission in these settings.

Disclaimer

PHE's rapid reviews aim to provide the best available evidence to decision makers in a timely and accessible way, based on published peer-reviewed scientific papers, unpublished reports and papers on preprint servers. Please note that the reviews: i) use accelerated methods and may not be representative of the whole body of evidence publicly available; ii) have undergone an internal, but not independent, peer review; and iii) are only valid as of the date stated on the review.

In the event that this review is shared externally, please note additionally, to the greatest extent possible under any applicable law, that PHE accepts no liability for any claim, loss or damage arising out of, or connected with the use of, this review by the recipient and/or any third party including that arising or resulting from any reliance placed on, or any conclusions drawn from, the review.

References

1. Dirlikov E and others. 'CDC Deployments to State, Tribal, Local, and Territorial Health Departments for COVID-19 Emergency Public Health Response - United States, January 21-July 25, 2020'. MMWR - Morbidity & Mortality Weekly Report 2020: volume 69, issue 39, pages 1398-403
2. ECDC. 'COVID-19 clusters and outbreaks in occupational settings in the EU/EEA and the UK (11 AUgust 2020)'. Stockholm: ECDC 2020:
3. Page AJ and others. 'Large scale sequencing of SARS-CoV-2 genomes from one region allows detailed epidemiology and enables local outbreak management'. MedRxiv (preprint) 2020, pages 2020.09.28.20201475
4. Richmond CS and others. 'Interregional SARS-CoV-2 spread from a single introduction outbreak in a meat-packing plant in northeast Iowa'. MedRxiv (preprint) 2020, pages 2020.06.08.20125534
5. European Federation of Food Agriculture and Tourism Trade (EFFAT). 'Covid-19 outbreaks in slaughterhouses and meat processing plants (30 June 2020)'. 2020:
6. Kopechek JA. 'Increased ambient noise and elevated vocal effort contribute to airborne transmission of COVID-19'. Journal of the Acoustical Society of America 2020: volume 148, issue 5, pages 3255
7. Morris DH and others. 'The effect of temperature and humidity on the stability of SARS-CoV-2 and other enveloped viruses'. BioRxiv (preprint) 2020, pages 2020.10.16.341883
8. Gunther T and others. 'SARS-CoV-2 outbreak investigation in a German meat processing plant'. EMBO molecular medicine 2020, pages e13296
9. Steinberg J and others. 'COVID-19 Outbreak Among Employees at a Meat Processing Facility - South Dakota, March-April 2020'. MMWR - Morbidity & Mortality Weekly Report 2020: volume 69, issue 31, pages 1015-9
10. Donahue M and others. 'Notes from the Field: Characteristics of Meat Processing Facility Workers with Confirmed SARS-CoV-2 Infection - Nebraska, April-May 2020'. MMWR - Morbidity & Mortality Weekly Report 2020: volume 69, issue 31, pages 1020-2
11. Dyal JW and others. 'COVID-19 Among Workers in Meat and Poultry Processing Facilities - 19 States, April 2020'. MMWR Morbidity & Mortality Weekly Report 2020: volume 69, issue 18, pages 08
12. Waltenburg MA and others. 'Update: COVID-19 Among Workers in Meat and Poultry Processing Facilities - United States, April-May 2020'. MMWR - Morbidity & Mortality Weekly Report 2020: volume 69, issue 27, pages 887-92
13. Waltenburg MA and others. 'Coronavirus Disease among Workers in Food Processing, Food Manufacturing, and Agriculture Workplaces'. Emerging Infectious Diseases 2020: volume 27, issue 1, pages 19
14. Rubenstein BL and others. 'Factors That Might Affect SARS-CoV-2 Transmission Among Foreign-Born and U.S.-Born Poultry Facility Workers - Maryland, May 2020'. MMWR - Morbidity & Mortality Weekly Report 2020: volume 69, issue 50, pages 1906-10
15. Center KE and others. 'Multidisciplinary Community-Based Investigation of a COVID-19 Outbreak Among Marshallese and Hispanic/Latino Communities - Benton and Washington Counties, Arkansas, March-June 2020'. MMWR - Morbidity & Mortality Weekly Report 2020: volume 69, issue 48, pages 1807-11

Annexe A. Methodology

Literature search

This report employed a rapid review approach to address the review question:

What factors contribute to the transmission of COVID-19 in food manufacturing and processing settings?

Protocol

A protocol was produced by the project team before the literature search began, specifying the research question and the inclusion and exclusion criteria. The protocol is available in Annexe C.

Sources searched

Medline, Embase, medRxiv preprints, WHO COVID-19 Research Database, Food Science and Technology Abstracts, Google Scholar and Google.

Search strategy

Searches were conducted for papers published between 1 January 2020 and 21 December 2020.

Search terms covered key aspects of the research question. The search strategy for Ovid Medline is presented below.

Reference lists of relevant papers were also searched.

Search strategy for Ovid Medline

1. (food adj3 process*).tw,kw.
2. (meat adj3 process*).tw,kw.
3. (poultry adj3 process*).tw,kw.
4. (seafood adj3 process*).tw,kw.
5. (fish adj3 process*).tw,kw.
6. (chicken adj3 process*).tw,kw.
7. (fruit adj3 process*).tw,kw.
8. ((veg or vegetable*) adj3 process*).tw,kw.
9. ((food or meat or poultry or chicken or fish or seafood) and (factory or factories)).tw,kw.
10. (meatpacking or meat packing).tw,kw.
11. meat industr*.tw,kw.
12. food industr*.tw,kw.
13. seafood industr*.tw,kw.
14. slaughter*.tw,kw.
15. (food adj2 plant*).tw,kw.
16. (meat adj2 plant*).tw,kw.

17. (food* adj2 setting).tw,kw.
18. industrial setting*.tw,kw.
19. production line*.tw,kw.
20. ((factory or factories) adj2 work*).tw,kw.
21. food production.tw,kw.
22. food manufactur*.tw,kw.
23. (indoor* adj3 (rest area* or smoking area* or work*)).tw,kw.
24. (work* adj2 (transport* or language* or socialis* or living or ride-share* or carpool* or car-share* or close* or canteen*)).tw,kw.
25. (low income adj2 work*).tw,kw.
26. process* facilit*.tw,kw.
27. ((factory or factories or process* or warehouse*) and (outbreak* or closure* or close*)).tw,kw.
28. refrigerat*.tw,kw.
29. cold environment*.tw,kw.
30. abattoir*.tw,kw.
31. Food-Processing Industry/
32. exp Meat-Packing Industry/
33. Abattoirs/
34. Fisheries/
35. Refrigeration/
36. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35
37. exp coronavirus/
38. exp Coronavirus Infections/
39. ((corona* or corono*) adj1 (virus* or viral* or virinae*)).ti,ab,kw.
40. (coronavirus* or coronovirus* or coronavirinae* or CoV or HCoV*).ti,ab,kw.
41. covid*.nm.
42. (2019-nCoV or 2019nCoV or nCoV2019 or nCoV-2019 or COVID-19 or COVID19 or CORVID-19 or CORVID19 or WN-CoV or WNCoV or HCoV-19 or HCoV19 or 2019 novel* or Ncov or n-cov or SARS-CoV-2 or SARSCoV-2 or SARSCoV2 or SARS-CoV2 or SARSCov19 or SARS-Cov19 or SARSCov-19 or SARS-Cov-19 or Ncovor or Ncorona* or Ncorono* or NcovWuhan* or NcovHubei* or NcovChina* or NcovChinese* or SARS2 or SARS-2 or SARScoronavirus2 or SARS-coronavirus-2 or SARScoronavirus 2 or SARS coronavirus2 or SARScoronovirus2 or SARS-coronovirus-2 or SARScoronovirus 2 or SARS coronovirus2).ti,ab,kw.
43. (respiratory* adj2 (symptom* or disease* or illness* or condition*) adj10 (Wuhan* or Hubei* or China* or Chinese* or Huanan*)).ti,ab,kw.
44. ((seafood market* or food market* or pneumonia*) adj10 (Wuhan* or Hubei* or China* or Chinese* or Huanan*)).ti,ab,kw.
45. ((outbreak* or wildlife* or pandemic* or epidemic*) adj1 (Wuhan* or Hubei or China* or Chinese* or Huanan*)).ti,ab,kw.
46. or/37-45
47. 36 and 46
48. limit 47 to yr="2020"

Inclusion and exclusion criteria

Table 1. Inclusion and exclusion criteria

	Included	Excluded
Population	Human	Non-human studies
Settings	Food manufacturing and processing settings, including meat-production settings. Evidence at international level will be considered.	Food business other than food manufacturing and processing, such as farms, supermarkets, etc.
Context	COVID-19 outbreak	Other diseases
Exposure	Any factors contributing to transmission will be considered, for example: • working environment (handling of meat, temperature, humidity, type of surfaces, ventilation, proximity between workers, use of personal protective equipment) • onsite areas (canteens, bathrooms) • demographics of workers (age, gender, socioeconomic status, living conditions)	
Outcomes	• transmission of COVID-19 • COVID-19 infection rate • COVID-19 outbreaks in food manufacturing and processing settings	
Language	English	
Date of publication	1 January 2020 to 21 December 2020	
Study design	• experimental or observational studies • case series, case reports and surveillance reports • modelling studies	• systematic reviews • guidelines • opinion pieces
Publication type	Published and pre-print Grey literature	

Screening

Title and abstract screening were done by 2 reviewers: 10% of the eligible studies were screened in duplicate (disagreements were resolved by discussion) and the remainder were screened by one reviewer.

Full text screening was done by one reviewer and checked by another reviewer. Disagreements were resolved by discussion with a third reviewer.

Figure 1 illustrates this process.

Data extraction and quality assessment

Summary information for each study was extracted and reported in tabular form. This was undertaken by one reviewer and checked by a second.

Due to the rapid nature of the work, a validated risk of bias tool was not used to assess study quality. However, major sources of bias were noted when reviewing the papers (mainly population, selection, exposure and outcome).

Variations across populations and subgroups, for example cultural variations or differences between ethnic, social or vulnerable groups were considered, where evidence is available.

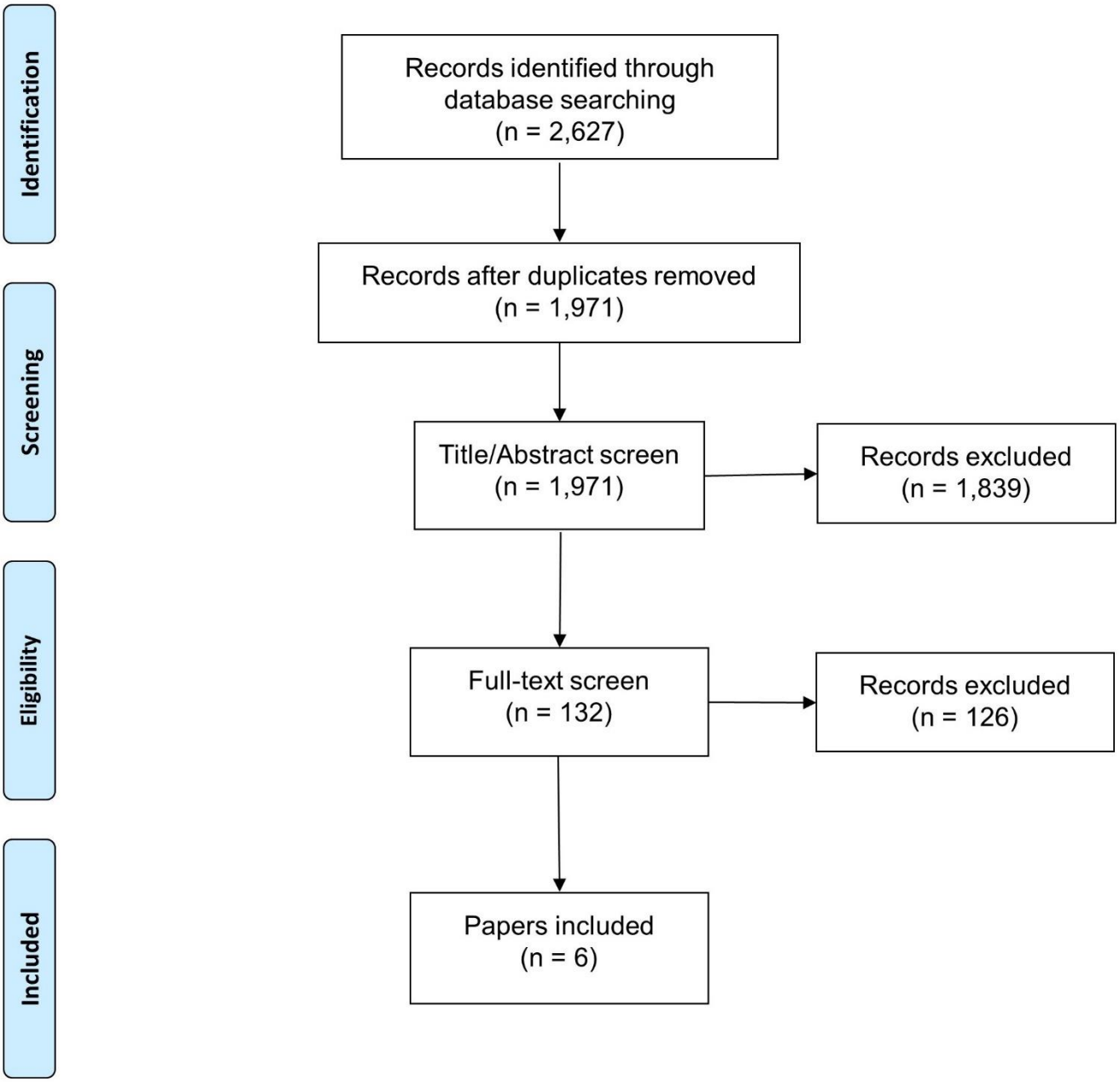

Figure 1. PRISMA diagram

Accessible text version of figure 1

A PRISMA diagram showing the flow of studies through this review, including n=2,627 studies identified through database searching.

From these, records removed before screening were:

Duplicate records removed (n=656)

n=1,971 records screened of which n=1,839 were excluded, leaving n=132 papers sought for retrieval.

n=126 papers were excluded, leaving n=6 papers included.

Annexe B. Data extraction

Table 2. Data extraction table for COVID-19 outbreaks in food manufacturing or processing settings

Reference	Study design	Methods	Main findings	Risk of bias
Donahue and others, 2020 (10) 'Notes from the Field: Characteristics of Meat Processing Facility Workers with Confirmed SARS-CoV-2 Infection - Nebraska, April to May 2020'	**Study type** Outbreak investigation **Objective** To interview workers at a meat processing facility with confirmed SARS-CoV-2 infection to identify possible exposure **Settings** Meat processing facility (1,276 employees), Nebraska, US **Study period** Apri to May 2020	SARS-CoV-2 testing (RT-PCR) of all workers, followed by phone interviews with those who tested positive.	31% (375 of 1216) of workers tested positive. Of the 375 workers who had positive test results, 241 (69%) were interviewed. Of those who were interviewed: • 57% were male • 46% were Hispanic • 36% reported no symptoms • 29% reported a close contact with an ill person or positive COVID-19 at work (of which 74% in production areas and 51% in cafeteria/ rest areas) • 13% reported a close contact with an ill person or positive COVID-19 outside of work • 73% had flexible medical leave policy • 87% reported regular fever screening on arrival to work and 41% reported regular symptom checking Of the 167 employees who worked in the 14 days preceding symptom onset or testing, 46% reported working in close proximity to others (less than 1.5m) on the conveyor belt.	**Study type** Outbreak investigations do not have pre-determined research questions or methods, are uncontrolled (no comparator group) and are non representative (limited population). **Bias** Studies using interviews or surveys are at risk of recall bias. This study is at risk of inclusion bias at three stages due the agreement of interviewees to be tested, provide contact information and be interviewed. The demographic of non-responders can differ from responders. **Confounding** Results not adjusted for possible confounding factors. No information provided regarding

Reference	Study design	Methods	Main findings	Risk of bias
				local or state level COVID-19 prevalence at the time. Lack of detailed ethnicity information (Hispanic or non-hispanic only).

Dyal and others, 2020 (11)
 	
'COVID-19 Among Workers in Meat and Poultry Processing Facilities - 19 States, April 2020'
	Study type
	Cross-sectional study
	
	Objective
	To collect surveillance data for workers in all meat and poultry processing facilities affected by COVID-19
	
	Settings
	Meat and poultry processing facilities, US.
	
	Study period
	Up to 27 April 2020
		In April 2020, CDC requested data from states that reported COVID-19 outbreaks in meat or poultry facilities
		
		Analysis of qualitative data from risk assessments.
			Aggregated data received from 23 states, of which 19 had reported at least one case in these facilities. Among these 19 states:
			• 115 meat or poultry facilities had recorded COVID-19 cases
			• 4,913 workers had been diagnosed with COVID-19, which corresponds to 3% of the workers (ranging from 0.3% to 18.2%)
			
			Factors that might have increased risk for transmitting or acquiring COVID-19 (identified through analysis of the qualitative data from the facility risk assessments):
			• structural and operational challenges
			  ○ maintaining 2-metre distance while working
			  ○ adhering to face covering recommendations due to the nature of the work
			  ○ adhering to cleaning and disinfection guidance
			• sociocultural and economic challenges:
			  ○ diverse background, different primary languages
			  ○ incentive to work while ill
			  ○ many workers live in crowded, multigenerational settings
				Study type
				Cross sectional studies are susceptible to inclusion bias and are uncontrolled (no comparator group).
				
				Bias
				Response from just over half of states. The demographic of non-responders can differ from responders.
				No information about facilities with no cases.
				Data collection practice different according to location and no information on testing availability in various states and facilities.
				The individual-level data on each outbreak were not provided.
				
				Confounding
				Results not adjusted for possible confounding factors.

Reference	Study design	Methods	Main findings	Risk of bias
			○ some workers share transportation to and from work	Source of infection not guaranteed to be from food facilities - community transmission cannot be excluded.
Gunther and others, 2020 (8) 'SARS-CoV-2 outbreak investigation in a German meat processing plant'	**Study type** Outbreak investigation **Objective** To study an outbreak of COVID-19 in 2 meat processing plants 30km apart: MPP-D (279 employees) and MPP-R (6,289 employees) **Settings** Meat processing plants **Study period** May to June 2020	SARS-CoV-2 testing (RT-PCR) of all staff in MPP-D and MPP-R Investigation included: infectious event timing, spatial, climate and ventilation conditions, virus genome sequencing, and living quarter and shared commuting practices.	**Testing and timeline** - Week of 11 May 2020: • 34% MPP-D employees (94 out of 279) positive • 0.06% MPP-R employees (4 out of 6,289) positive - 17 May: contact between 2 MPP-R workers (B1 and B2) and 2 MPP-D workers (D1 and D2) who then tested positive - first outbreak in MPP-R: B1, B2 and 29 (of 140) workers on the same shift tested positive (exposure between 18-20 May, test results between 21 May and 3 June) - throughout June 2020 (second outbreak), more than 1,400 COVID-19 cases were identified at MPP-R **Genotype analyses** - 8 mutations were present with near 100% frequency across all samples tested in MPP-R; 2 of these were new mutations (not yet registered in GISAID) which suggest that the virus circulating in MPP-R was a new sub-branch of an existent variant - D2 and B1 shared the same set of 8 mutations, while B2 had an additional mutation. This additional mutation was present at about 20% in D1, which suggests that	**Study type** Outbreak investigations do not have pre-determined research questions or methods, are uncontrolled (no comparator group) and are non representative (limited population). **Bias** Information regarding employees were not independently verified and were provided by the employer. Data on race and ethnicity were not provided. **Confounding** Results not adjusted for possible confounding factors. Individual risk factors not accounted for as no information provided on workers (demographics, health status, etc).

Reference	Study design	Methods	Main findings	Risk of bias
			D1 might have been the common source of infection to B1 and B2 - first outbreak in MPP-R: analysis of B1, B2 and 18 cases suggests that B1 was the common source of infection in the cluster (13 out of 18 cases shared the same viral genome signature than B1; the others had the same 8 mutations + 1 or 2 additional mutations), although it cannot be ruled out that at least some of the cases could be independent infection events - second outbreak in MPP-R: analysis of 15 cases suggests that cases in May to June shared the same viral genome signature (based on the same 8 mutations) **Possible transmission routes** - first outbreak: • potential universal contact was the beef processing plant where most workers are at fixed positions on a conveyor-belt processing line • analyses of spatial relationship was conducting, by mapping the positions of all RT-PCR-tested employees (suspected primary cases, secondary cases, and negative cases) in the processing plant, including data on test results and virus genotypes. Infection rate was then represented as a function of distance from the suspected index cases, suggesting	

Reference	Study design	Methods	Main findings	Risk of bias
			that transmission occurred within a radius of up to 8m • the plant is equipped of a cooled recirculating unfiltered air handling system of 8 units, which might have promoted airborne transmission • other factors that might have promoted airborne transmission include low fresh air exchange rates and intense physical exercise when working on the plant - Shared commuting practices were reported within workers (living spaces and carpooling) but the investigation suggested that most transmissions occurred within the meat processing facility	
Steinberg and others, 2020 (9) 'COVID-19 Outbreak Among Employees at a Meat Processing Facility - South Dakota, March to April 2020'	**Study type** Outbreak investigation **Objective** To investigate COVID-19 outbreak to isolate index case and identify and quarantine contacts. **Settings** Meat processing facility (3,635	All reported cases were investigated to determine patient symptom onset date, contact tracing, and to describe the individuals illness clinical course. **Definitions**: • COVID-19 case: positive SARS-CoV-2 (RT-PCR) with or without	25.6% of employees were diagnosed with COVID-19, of which 96.3% were symptomatic. Between 16 March and 25 April, attack rate at facility was 25.6%, with the highest attack rate in the cut (30.2%), conversion (30.1%) and Harvest (29.4%) departments where employees tend to work less than 2 meters apart on the production line. The attack rate was higher among non-salaried employees (26.8%) than among salaried employees (14.8%) who tend to have workstations where social distancing can be maintained.	**Study type** Outbreak investigations do not have pre-determined research questions or methods, are uncontrolled (no comparator group) and are non representative (limited population). **Bias** Asymptomatic employees had limited testing. Therefore risk of underestimation of number of cases within the population investigated.

Reference	Study design	Methods	Main findings	Risk of bias
	employees), South Dakota, US **Study period** March to April 2020	symptoms, before 26 April (=14 days after phased closure) • attack rate: proportion of employees with COVID-19		Attack rates stratified by race and ethnicity are not reported due to incomplete data. **Confounding** Results not adjusted for possible confounding factors, such as individual risk factors and control measures introduced before plant closure. Employee testing decreased after facility closure, which also might have contributed to the apparent reduction in cases.
Waltenburg and others, 2020 (12) Update: COVID-19 Among Workers in Meat and Poultry Processing Facilities - United States, April to May 2020	**Study type** Cross-sectional study **Objective** To collect surveillance data for workers in all meat and poultry processing facilities affected by covid-19. **Settings**	Analyses of data on demographic characteristics and symptom status of workers with COVID-19 in meat and poultry processing plants as reported by the states.	- Aggregated data received from 28 states, of which 23 reported at least one confirmed COVID-19 case. Among these 23 states: • 239 meat or poultry facilities had recorded laboratory-confirmed COVID-19 cases • 16,233 workers had been diagnosed with COVID-19 - 14 states reported total number of workers, of which 9.1% had tested positive to SARS-Cov-2, ranging from 3.1% to 24.5% per facility 21 states that had reported data on demographic characteristics and symptoms:	**Study type** Cross sectional studies are susceptible to inclusion bias and are uncontrolled (no comparator group). **Bias** Response from just over half of states. The demographic of non-responders can differ from responders. No information about facilities with no cases.

Reference	Study design	Methods	Main findings	Risk of bias
	Meat and Poultry Processing Facilities, United States **Study period** Up to 31 May 2020		• 60% of cases in male (among the 12,100 cases with info on sex) • 46% of cases aged 40 to 59 years old (among the 12,365 cases with info on age) • 88% of workers were symptomatic (among the 10,284 cases with symptom status) • among the 9,919 cases with race and/or ethnicity reported, 56% were Hispanic, 19% were Black, 13% were White, and 12% were Asian, suggesting that Hispanic and Asian workers might be disproportionately affected by COVID-19 in this workplace setting (within animal slaughtering and processing workers in these 21 states, 30% are Hispanic and 6% Asian).	Data collection practice different according to location and no information on testing availability in various states and facilities. **Confounding** Results not adjusted for possible confounding factors. Source of infection not guaranteed to be from food facilities - community transmission cannot be excluded.
Waltenburg and others, 2020 (13) Coronavirus Disease among Workers in Food Processing, Food Manufacturing, and Agriculture Workplaces	**Study type** Cross-sectional study **Objective** To collect surveillance data for workers in agriculture, food and food processing facilities affected by COVID-19, and to update information	Analyses of data on demographic characteristics and symptom status of workers with COVID-19 as reported by the states health departments.	Agriculture settings being excluded from this rapid review, only the results related to meat and poultry facilities have been reported. Aggregated data received from 31 with at least one confirmed COVID-19 case. Among these 31 states: • 382 meat or poultry facilities had recorded COVID-19 cases • 28,364 workers had been diagnosed with COVID-19 Of the laboratory-confirmed COVID-19 cases among workers in meat and poultry processing, 60% were male and nearly 90% were symptomatic.	**Study type** Cross sectional studies are susceptible to inclusion bias and are uncontrolled (no comparator group). **Bias** Results might not be representative of all states as this study includes data from only 31 states. The demographic of non-responders can differ from responders. No information about

Reference	Study design	Methods	Main findings	Risk of bias
Note: this paper is available as an early release and cannot be considered as a final version	on COVID-19 among meat and poultry processing workers **Settings** Food manufacturing and agriculture workplaces, United States **Study period** Up to 31 May 2020		Nearly 60% of cases were Hispanic or Latino (36.5% of all food manufacturing and agriculture workers in 28 states reporting race and ethnicity data are Hispanic or Latino)	facilities with no cases and no information on testing availability in various states and facilities. **Confounding** Results not adjusted for possible confounding factors. No information on demographic characteristics of the workplaces provided. Source of infection not guaranteed to be from food facilities - community transmission cannot be excluded.

Annexe C. Protocol

COVID-19 outbreaks in food processing settings: rapid review protocol

Review question:
“What factors contribute to the transmission of COVID-19 in food manufacturing and processing settings?”

Eligibility criteria

	Included	Excluded
Population	Human	Non-human studies
Settings	Food manufacturing and processing settings, including meat-production settings. Evidence at international level will be considered.	Food business other than food manufacturing and processing, such as farms, supermarkets, etc.
Context	COVID-19 outbreak	Other diseases
Exposure	Any factors contributing to transmission will be considered, for example: • working environment (handling of meat, temperature, humidity, type of surfaces, ventilation, proximity between workers, use of personal protective equipment) • onsite areas (canteens, bathrooms) • demographics of workers (age, gender, socioeconomic status, living conditions)	
Outcomes	• transmission of COVID-19 • COVID-19 infection rate • COVID-19 outbreaks in food manufacturing and processing settings	
Language	English	
Date of publication	1 January 2020 to 21 December 2020	
Study design	• experimental or observational studies • case series, case reports and surveillance reports • modelling studies	• systematic reviews • guidelines • opinion pieces
Publication type	Published and pre-print	

	Included	Excluded
	Grey literature	

Sources of evidence
Medline, Embase, medRxiv preprints, WHO COVID-19 Research Database, Food Science and Technology Abstracts, Google Scholar and Google.

Reference lists of relevant papers will also be searched.

Search strategy for Ovid Medline

1. (food adj3 process*).tw,kw.
2. (meat adj3 process*).tw,kw.
3. (poultry adj3 process*).tw,kw.
4. (seafood adj3 process*).tw,kw.
5. (fish adj3 process*).tw,kw.
6. (chicken adj3 process*).tw,kw.
7. (fruit adj3 process*).tw,kw.
8. ((veg or vegetable*) adj3 process*).tw,kw.
9. ((food or meat or poultry or chicken or fish or seafood) and (factory or factories)).tw,kw.
10. (meatpacking or meat packing).tw,kw.
11. meat industr*.tw,kw.
12. food industr*.tw,kw.
13. seafood industr*.tw,kw.
14. slaughter*.tw,kw.
15. (food adj2 plant*).tw,kw.
16. (meat adj2 plant*).tw,kw.
17. (food* adj2 setting).tw,kw.
18. industrial setting*.tw,kw.
19. production line*.tw,kw.
20. ((factory or factories) adj2 work*).tw,kw.
21. food production.tw,kw.
22. food manufactur*.tw,kw.
23. (indoor* adj3 (rest area* or smoking area* or work*)).tw,kw.
24. (work* adj2 (transport* or language* or socialis* or living or ride-share* or carpool* or car-share* or close* or canteen*)).tw,kw.
25. (low income adj2 work*).tw,kw.
26. process* facilit*.tw,kw.
27. ((factory or factories or process* or warehouse*) and (outbreak* or closure* or close*)).tw,kw.
28. refrigerat*.tw,kw.
29. cold environment*.tw,kw.
30. abattoir*.tw,kw.
31. Food-Processing Industry/
32. exp Meat-Packing Industry/
33. Abattoirs/
34. Fisheries/

35. Refrigeration/
36. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35
37. exp coronavirus/
38. exp Coronavirus Infections/
39. ((corona* or corono*) adj1 (virus* or viral* or virinae*)).ti,ab,kw.
40. (coronavirus* or coronovirus* or coronavirinae* or CoV or HCoV*).ti,ab,kw.
41. covid*.nm.
42. (2019-nCoV or 2019nCoV or nCoV2019 or nCoV-2019 or COVID-19 or COVID19 or CORVID-19 or CORVID19 or WN-CoV or WNCoV or HCoV-19 or HCoV19 or 2019 novel* or Ncov or n-cov or SARS-CoV-2 or SARSCoV-2 or SARSCoV2 or SARS-CoV2 or SARSCov19 or SARS-Cov19 or SARSCov-19 or SARS-Cov-19 or Ncovor or Ncorona* or Ncorono* or NcovWuhan* or NcovHubei* or NcovChina* or NcovChinese* or SARS2 or SARS-2 or SARScoronavirus2 or SARS-coronavirus-2 or SARScoronavirus 2 or SARS coronavirus2 or SARScoronovirus2 or SARS-coronovirus-2 or SARScoronovirus 2 or SARS coronovirus2).ti,ab,kw.
43. (respiratory* adj2 (symptom* or disease* or illness* or condition*) adj10 (Wuhan* or Hubei* or China* or Chinese* or Huanan*)).ti,ab,kw.
44. ((seafood market* or food market* or pneumonia*) adj10 (Wuhan* or Hubei* or China* or Chinese* or Huanan*)).ti,ab,kw.
45. ((outbreak* or wildlife* or pandemic* or epidemic*) adj1 (Wuhan* or Hubei or China* or Chinese* or Huanan*)).ti,ab,kw.
46. or/37-45
47. 36 and 46
48. limit 47 to yr="2020"

Screening

Screening on title and abstract will be undertaken in duplicate by 2 reviewers for at least 10% of the eligible studies. Disagreement will be resolved by discussion.

Screening on full text will be undertaken by one reviewer and checked by a second.

Data extraction

Summary information for each study will be extracted and reported in tabular form. This will be undertaken by one reviewer and checked by a second.

Risk of bias assessment

Due to the rapid nature of the work, validated tools will not be used for primary studies; however, papers will be evaluated based on study design and main source of bias (mainly population, selection, exposure and outcome).

Synthesis

A narrative synthesis will be provided.

Variations across populations and subgroups, for example cultural variations or differences between ethnic, social or vulnerable groups will be considered, where evidence is available.

About Public Health England

Public Health England exists to protect and improve the nation's health and wellbeing, and reduce health inequalities. We do this through world-leading science, knowledge and intelligence, advocacy, partnerships and the delivery of specialist public health services. We are an executive agency of the Department of Health and Social Care, and a distinct delivery organisation with operational autonomy. We provide government, local government, the NHS, Parliament, industry and the public with evidence-based professional, scientific and delivery expertise and support.

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